Point and integrated yield in the GOSIA code

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OUTLINE

Our goal is to calculate gamma yieds

- What the yield is ?
  - **Point** Yield vs. **Integrated** Yield
- What they are needed for ?
- What is needed to calculate it ?
  - Definition of the nucleus considered
  - Definition of the experiment

YIELD

GOSIA recognizes two types of yields:

- **Point yields** calculated for:
  - Excited levels layout
  - Collision partner
  - Matrix element values
  - **CHOSEN particle energy and scattering angle**
- **Integrated yields** calculated for:
  - (... as above but ...)
  - **A RANGE of scattering angles and energies**

POINT YIELD

How **GOSIA** does it?

- Assumes nucleus properties and collision partner;
- starts with **experimental conditions** (angle, energy) and **matrix element set**
- solves differential equations to find **level populations**;
- calculates **deexcitation** using gamma detection geometry, angular distributions, deorientation and internal conversion into acount.

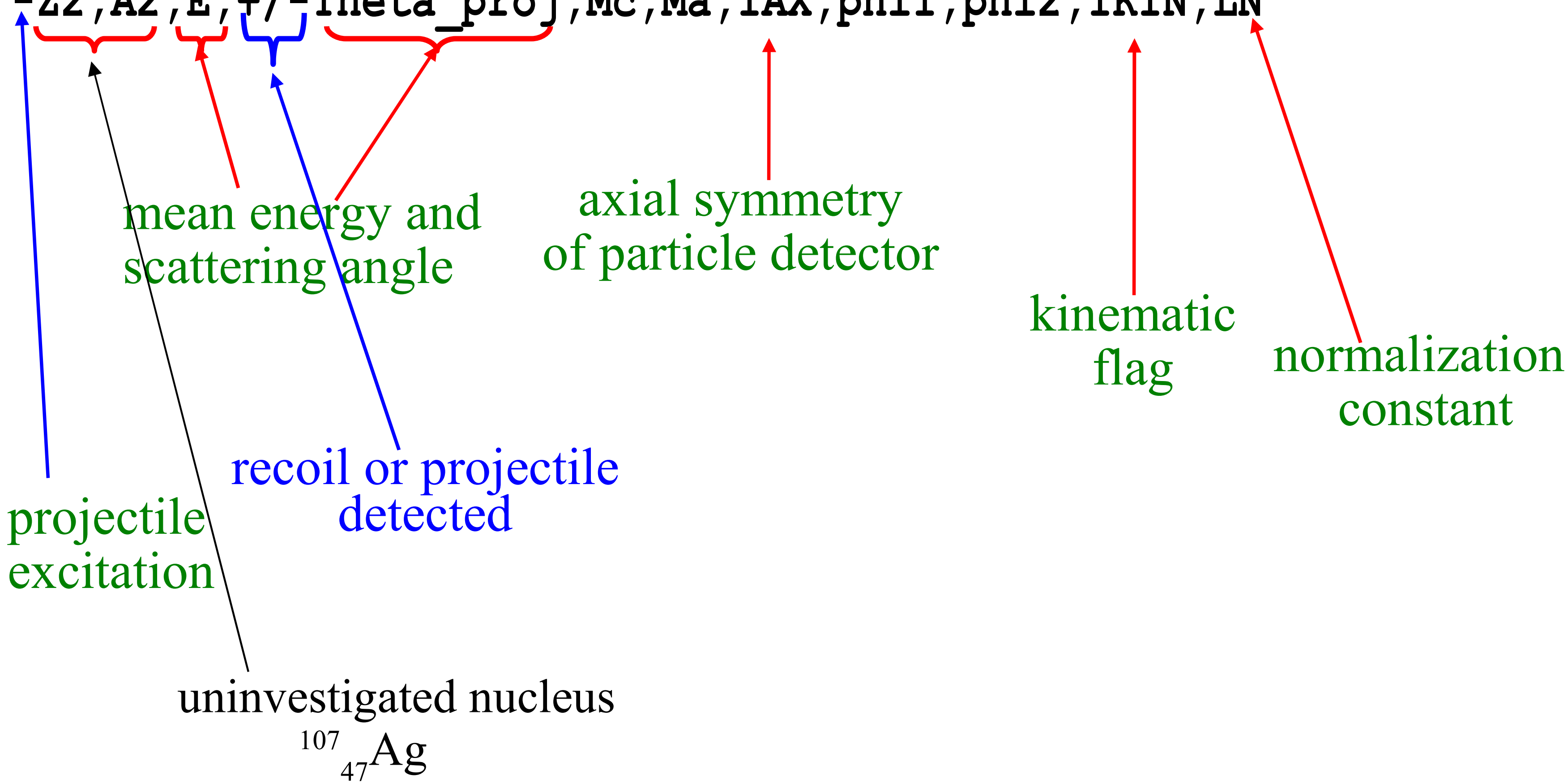
POINT YIELD

- are fast to be calculated...
- ...so they are used at minimisation stage
- **OP,POIN** – if one needs a quick look

- **but** are good for **one energy** and **one** (particle scattering) **angle**

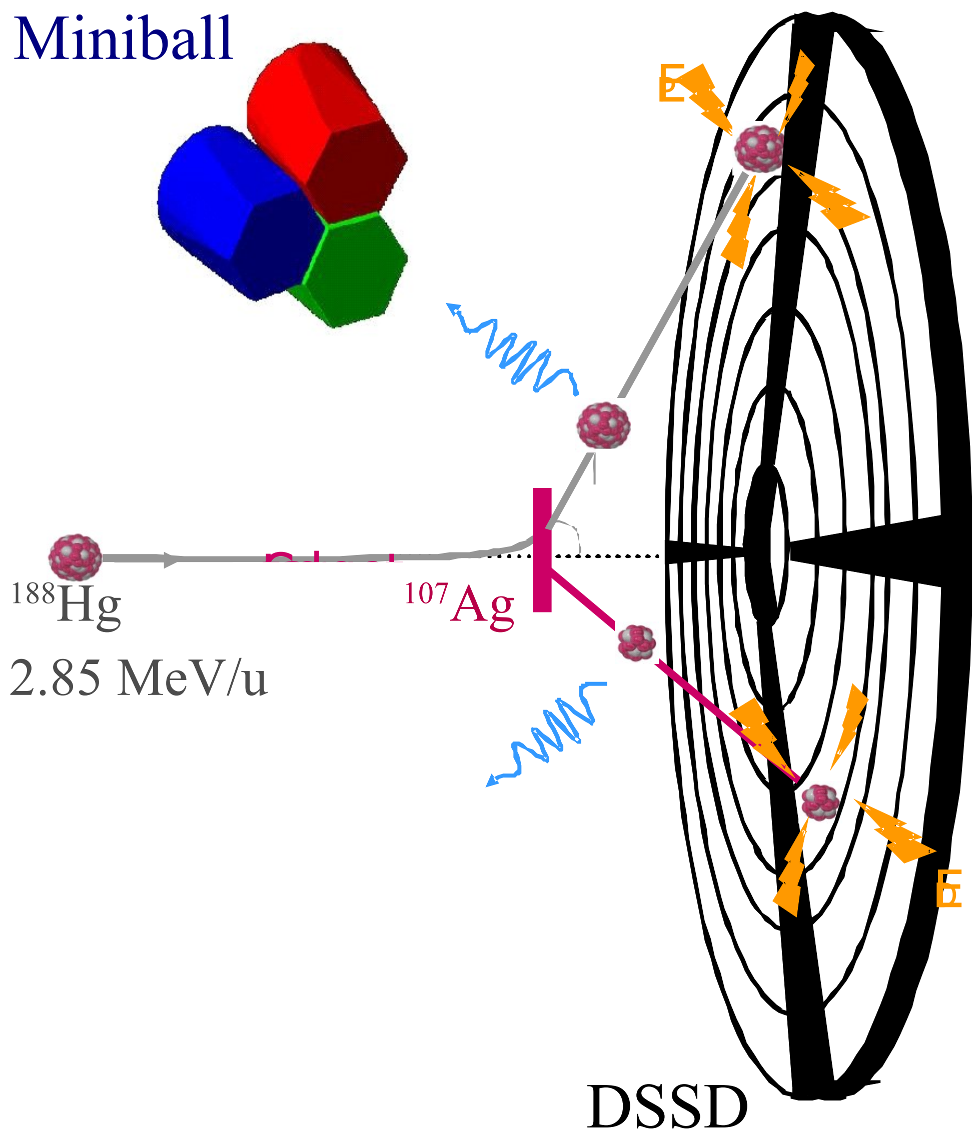
$^{188}_{80}$Hg beam bombarding $^{107}_{47}$Ag target

```
EXPT              ! inverse kinematic declaration
nexp,Z1,A1        ! investigated nucleus 188/80 Hg
-Z2,A2,E,+/-Theta_proj,Mc,Ma,IAX,phi1,phi2,IKIN,LN
```



INTEGRATED YIELD

- are something close to reality – reproduction of the experimentally observed yields requires integration over scattering angles and energy
- but quite **slow** to calculate **(OP,INTG)**



YIELD CORRECTION

- **Correction Factors** can be found by comparison of **calculated point** and **integrated** yields.

$$\mathbf{CF} = \frac{Y_P}{Y_I}$$

- Corrected yield: $\mathbf{Y^c_{exp} = Y_{exp} \cdot CF}$
- Correcting the yield is like averaging point yields over energy and angular range,
  - so the **better** the choice of mean energy/angle, **Correction Factor** is **closer to 1**.
- One needs as many C.F.s as gamma yields

$^{32}S + ^{100}Mo$, $\Theta_{scattering}$: $110^0 - 160^0$

EXPERIMENT 1 DETECTOR 1

$\Theta=140^0$ E=82 MeV

NI	NF	YEXP	YCOR	COR.F
7	5	.567E+03	.564E+03	.995E+00
6	2	.729E+03	.659E+03	.904E+00
6	3	.141E+04	.168E+04	.119E+01
5	2	.552E+05	.627E+05	.114E+01
4	1	.148E+05	.161E+05	.109E+01
4	2	.308E+05	.298E+05	.969E+00
4	3	.491E+03	.536E+03	.109E+01
3	2	.450E+05	.374E+05	.831E+00
2	1	.106E+07	.106E+07	.100E+01

EXPERIMENT 1 DETECTOR 1

$\Theta=125^0$ E=86.6 MeV

NI	NF	YEXP	YCOR	COR.F
7	5	.567E+03	.304E+02	.537E-01
6	2	.729E+03	.484E+02	.664E-01
6	3	.141E+04	.183E+01	.130E-02
5	2	.552E+05	.286E+06	.517E+01
4	1	.148E+05	.202E+03	.137E-01
4	2	.308E+05	.875E+05	.284E+01
4	3	.491E+03	.221E+02	.451E-01
3	2	.450E+05	.186E+06	.414E+01
2	1	.106E+07	.106E+07	.100E+01

YIELD CORRECTION

- **Correction** depends on the **matrix element set** so it is usually performed after satisfactory initial set is found.
- **Minimisation** is usually performed using **corrected yields**
- After minimisation, another correction should be performed with the new found **matrix element set** so the process is **recursive** but converges very well.

YIELD

- GOSIA calculates yields as differential cross sections, integrated over in-target particle energies and particle scattering angles
  - ‘differential’ in γ but **integrated** for particles
- The **‘GOSIA yield’** may be understood as a mean differential cross section multiplied by target thickness (in mg/cm^2)

$$[Y] = mb/sr \times mg/cm^2$$

Integration with OP,INTG

Few hints:

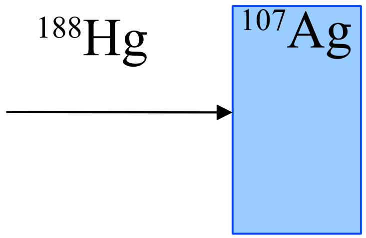
- Integration over angles: assume axial symmetry if possible (**IAX** suboption of **EXPT**)
- Theta and energy meshpoints have to be given manually.

Integration with OP,INTG

- Yield integration over energies: stopping power used to replace thickness with energy for integration:

$$\int_0^{thickness} Y dx = \int_{E\max}^{E\min} Y \frac{1}{\frac{dE}{dx}} dE$$

- One has to find projectile energy E_{min} at the end of the target to know the energy range for integration.



```
OP,INTG
NE,NT,Emin,Emax,TH1_proj,TH2_proj
E1,E2,E3,...                ! energy meshpoints
th1,th2,th3,...             ! theta meshpoints
NP                          ! number of stopping powers
E1,E2,E3,...                ! energy meshpoints
dE/dx,....                  ! stopping powers
NI1,NI2                     ! number of subdevisions of energy and scattering angle
OP,CORR                     ! to correct experimental yields
OP,EXIT
```

```
OP,INTG
NE,NT,Emin,Emax,TH1_proj,TH2_proj
E1,E2,E3,...                    ! energy meshpoints
th1,th2,th3,...                 ! theta meshpoints
NP                              ! number of stopping powers
E1,E2,E3,...                    ! energy meshpoints
dE/dx,....                      ! stopping powers
NI1,NI2                         ! number of subdevisions of energy and scattering angle
OP,CORR                         ! to correct experimental yields
OP,EXIT
```

more useful...

```
OP,INTI
NE,NT,Emin,Emax,TH1_det,TH2_det
```

← recoil or projectile detected

GOSIA yields

simulation of the experiments

YIELD ⇒ COUNT RATE

Fitting the matrix elements to the experimental data

$$\mathbf{Y}^{\mathbf{c}}_{\mathbf{exp}} = \mathbf{Y}_{\mathbf{exp}} \cdot \underbrace{\frac{Y_{POINT}}{Y_{INT}}}_{\mathbf{CF}}$$

YIELD $\Rightarrow$ COUNT RATE

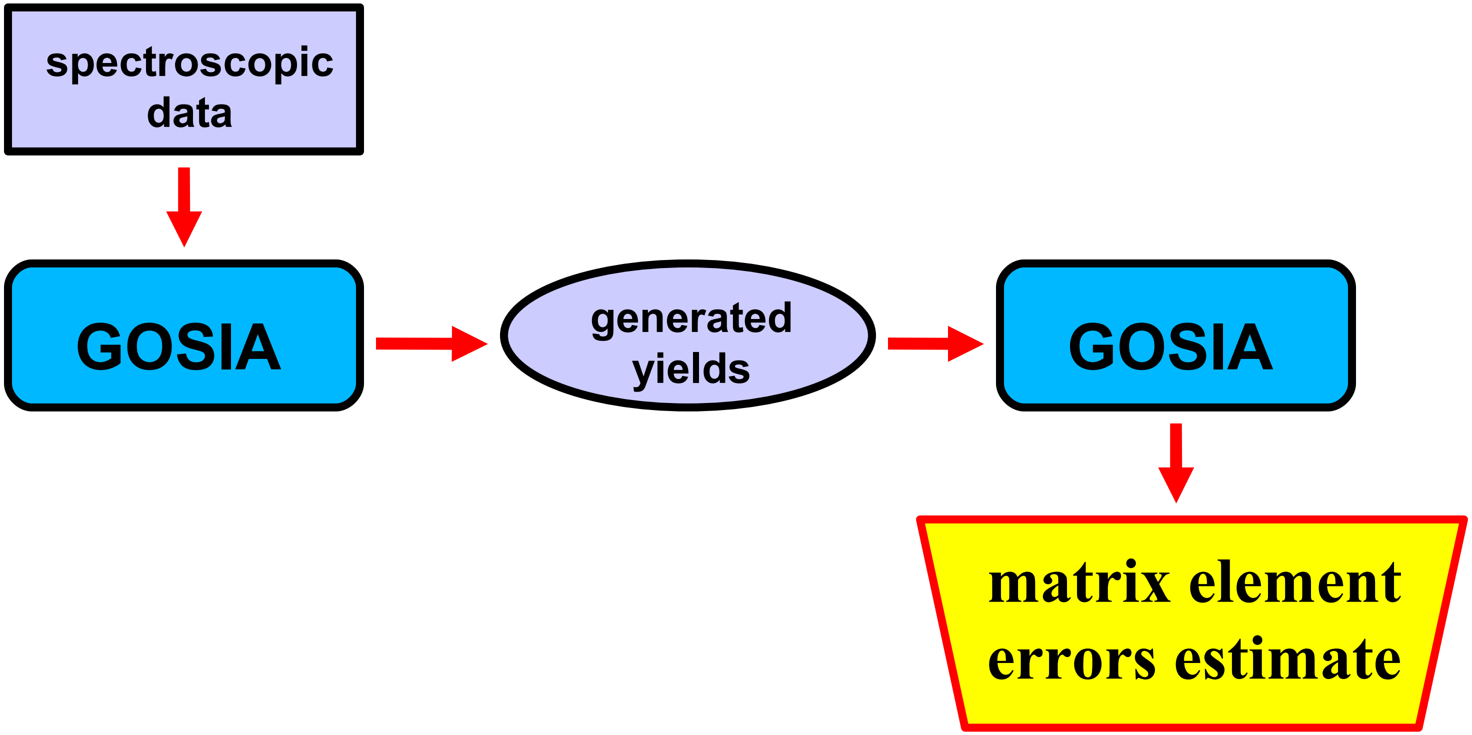
- **GOSIA** is aware of gamma detectors set-up
- Gamma yield depends on detector angle (angular distribution)
- However, angular distributions are flattened by detection geometry (both for **particle** and **gamma**)
- Gamma detector geometry is calculated at the initial stage (geometry correction factors are calculated and stored for yield calculation)

YIELD $\Rightarrow$ COUNT RATE

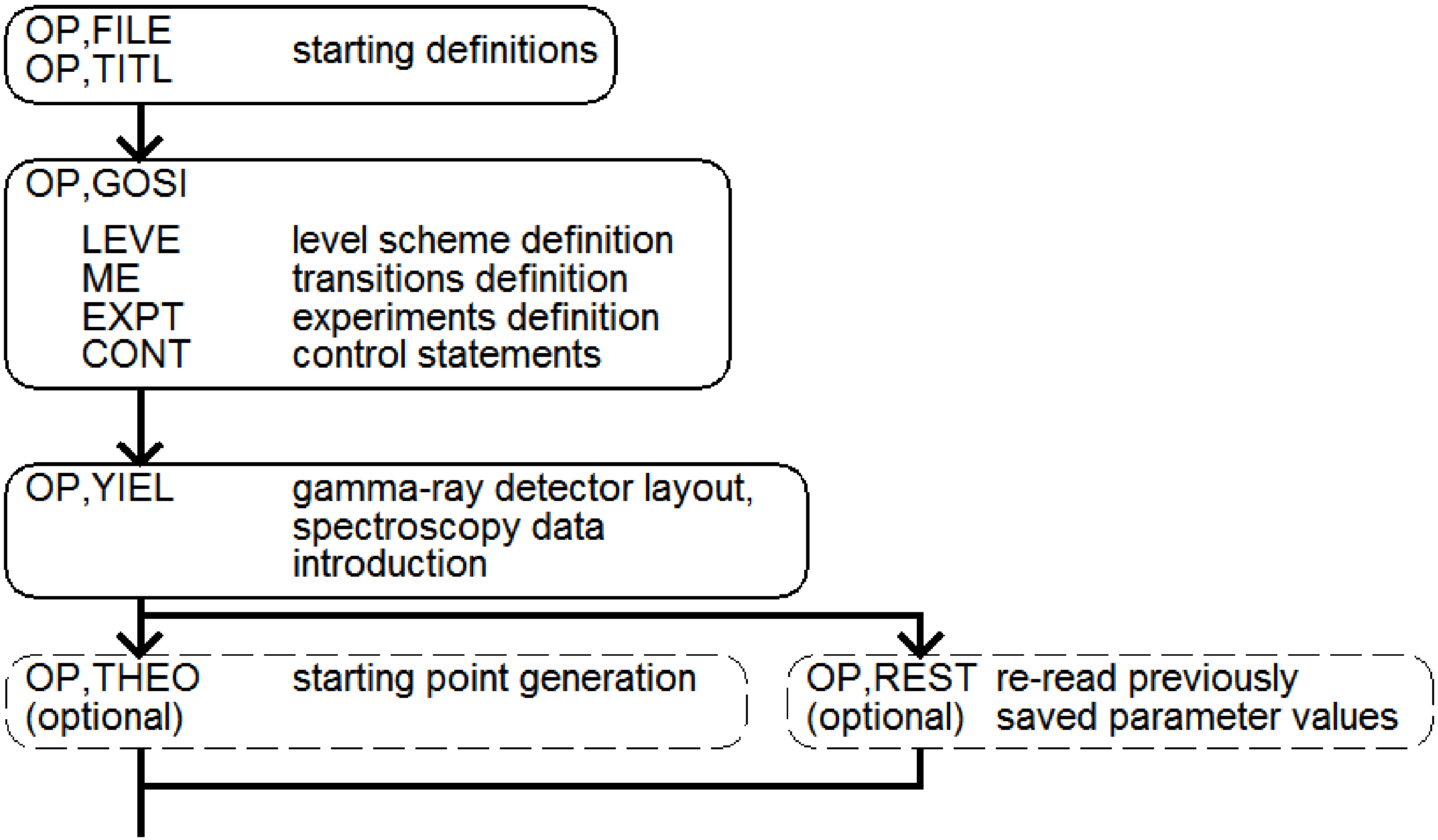
- Taking into account the solid angle, Avogadro number, barns etc, beam current, total efficiency...

$$\textbf{Count Rate} = \frac{7.6\times10^{-6}\times yield\times current[pps]\times eff}{A_{target}}$$

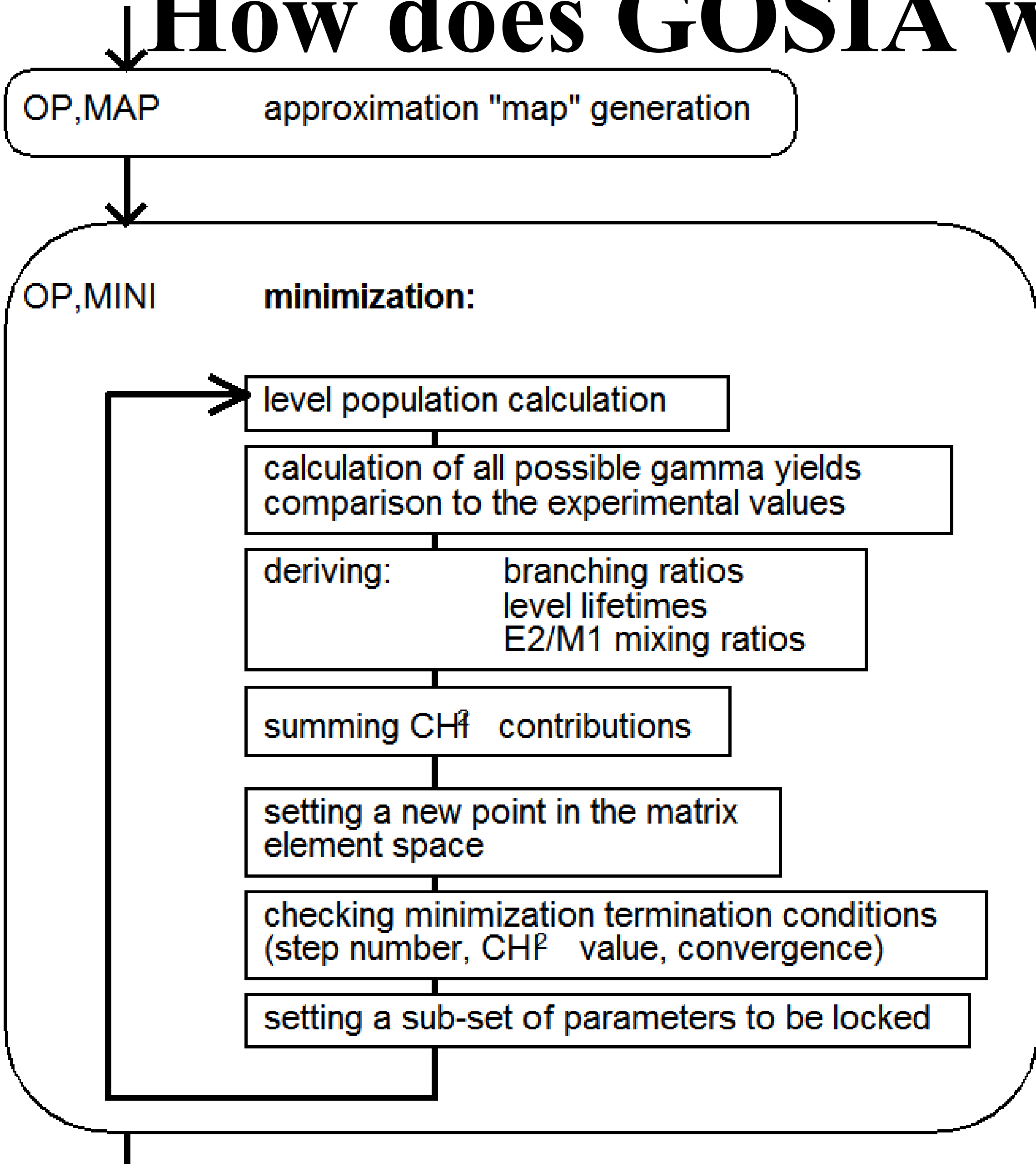
Having the yields calculated...



How does GOSIA work? (1/3)



How does GOSIA work? (2/3)



How does GOSIA work? (3/3)